Lab 3: Inverted Pendulum Compensator Design via Classical Control Techniques

I. Objective

The goal of this lab is:

- **a.** To design a controller using transfer function (classical) control techniques so as to balance the pendulum about the vertical equilibrium.
- **b.** To make sure students understand the limitations of classical control techniques in the context of multiple-input or multiple-output control systems.

II. Software and equipment

1. Computer with MATLAB, Simulink, WinCon and Real Time Workshop installed.
2. ee128 student account

III. Theory

1. Model of the Plant

Figure 1 below shows the inverted pendulum system's free body diagram from the previous lab for reference.

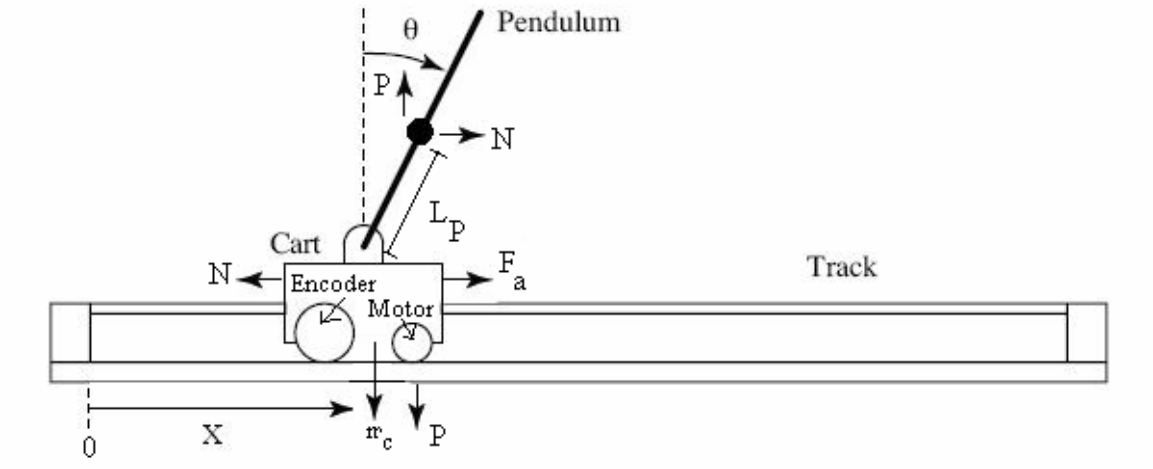

Figure 1. Pendulum system free body diagram [5].

IV. Prelab

1. Plant model

From your previous lab, write down your final plant model.

2. Controller design

Assuming that your input is the motor voltage and the output is the pendulum angle, design a controller that meets the following specifications:

1. Settling time is less than one second.
2. Pendulum angle is never more than 0.1 radians from the vertical.

You are free to use any classical control technique (root-locus, PID, frequency response etc.) that you wish. However, make sure that your work is logical and justified. A standard procedure to follow would be to start with the system's open-loop step response (say) and then use this to decide what kind of controller (lag, lead etc.) to design. Once this is done, use an appropriate technique to pick the controller gains.

Plot the response of the closed-loop system's cart position to a step input. Based on this result, can you implement this controller? Explain why or why not.

V. Lab

CAUTION: DO NOT TRANSFER DATA TO AND FROM THE WINDOWS 98 MACHINE. THIS MACHINE SHOULD NOT BE PUT ON THE EECS NETWORK!

0. Sign up for a 1-hour time slot with the TA.

1. Controller Implementation

Briefly describe your controller to the TA. Your presentation should be timed for 30 minutes, with a 15-minute Q/A session after your presentation. Make sure you address the design issues from the prelab.

VI. Revision History

Semester and Revision	Author(s)	Comments
Summer 2008 Rev. 1.00	Bharathwaj Muthuswamy	1. Formatted writeup into different sections. 2. Typed up solutions

VII. References

1. Franklin, Gene F., Powell, David J. and Emami-Naeini Abbas. *Feedback Control of Dynamic Systems.* 5th Edition. 2006, Prentice-Hall Inc.
2. UCSB course ECE147B: *Digital Control Systems Theory and Design.* Available online: http://www.ece.ucsb.edu/~roy/cgi-bin/makepage.pl?nav=course_147b June 27th 2008.
3. Quanser Consulting Inc. *Self Erecting IP User's Manual*, 1996.
4. Control Tutorials for MATLAB. Available Online: http://www.ee.usyd.edu.au/tutorials_online/matlab/examples/pend/invpen.html June 27th 2008